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Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER & SYSTEMS COMPANIES — WORLDWIDE

APRIL 17, 1989

THE MAKING OF... A NEW TI

How TI made its global IC strategies fly PAGE 26

CFOs keep watch on rising interest rates PAGE 17

Stakes rise in 3-D workstation market PAGE 74

Pat Weber,
TI's semiconductor
group president

Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES — WORLDWIDE

VOL. 17, NO. 8 APRIL 17, 1989

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In 1985, when Texas Instruments Inc.'s president, Jerry Junkins, told the Wall Street community he intended to remain in the memory business, he was told he was "crazy, suicidal." But now a $3 billion global IC operation has Junkins and semiconductor group president Pat Weber laughing at Wall Street. Along with the burgeoning sales and profits has come a new TI — one that's less arrogant, streamlined and doesn't revolve totally around Dallas anymore. Clearly, TI's "not invented here" syndrome is out.

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The DRAM business clearly helped TI — but for how much longer? Today, TI's strategy is to capitalize not only on DRAMs, but also on less noticeable areas such as digital signal processors and standard cells. And deal making, with the likes of Sun Microsystems Inc., hasn't hurt.

TI reshapes product lines along global responsibility

The key word for TI is global. So rather than having, say, separate memory managers in the United States, Japan and Europe, one worldwide manager is responsible in a profit and loss fashion.

Protecting the hard to protect: TI makes patents pay

Staying in memory has meant an aggressive "take no prisoners" attitude by TI to protect its patents. Over the past two years, the company has reaped about $315 million from infringers.

TI pioneers a market — DSP chips — and it pays

TI nurtured the digital signal processor market from virtually nothing to a 60% share today. Ironically, though, that may not be so appealing because as competitors catch up, TI can only lose market share.

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Office politics

A splendid story in the *Wall Street Journal* recently described the CEOs of the year 2000 — computer literate, multilingual, widely traveled folks who've hopped industries as comfortably as they've jumped company disciplines.

The new species is distinctly uneasy with Army-style hierarchies, preferring "offices of the CEO" where the boss is simply a first among equals and where consensus and teaming replace "head-honcho" diktats.

We're modeling ourselves that way too, and we feel that the resulting symbiosis will produce substantial benefits for our readers.

Instead of the traditional editorial structure, where the writers report to a managing editor, who, in turn, reports to the editor, we've set up a management triad — an "office of the editor," if you like — where the editor teams with an executive editor and a managing editor.

The executive editor — our new man is Jeff Bairstow, former *High Technology Business* senior staffer, accomplished editor and identifier of long-term industry trends — is the custodian of editorial quality. He is charged with assigning the right articles, ensuring that the incoming copy tells an informative story, and tells it accurately and attractively.

The managing editor — Roger Plant — takes up where Jeff leaves off: he's the expeditor who makes sure it comes in on time, to length and with all artwork complete; and who chases it through all succeeding production stages. Roger is a natural for the job — a seasoned production pro whose "big picture" view of the mechanics of putting a magazine to bed we couldn't do without.

From left: Roger Plant, managing editor and Jeff Bairstow, executive editor

Our intention is to bring you a magazine that offers the insight that the others don't. With Jeff and Roger as our top team, we feel we're positioned better than ever to make it happen.

JOHN KERR, editor

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VBPA ABP

The making of a new TI

For Texas Instruments' $3 billion IC operations, global is in and the "not invented here" syndrome is out. DRAM business clearly helped — but for how much longer?

BY VALERIE RICE

It is 1985, and Texas Instruments Inc.'s president Jerry Junkins has just told the Wall Street community he intends to keep TI in the memory business.

"They told me I was crazy, suicidal," Junkins, now chairman, recalls. "It made TI look stupid."

Today he and semiconductor group president William "Pat" Weber are laughing at Wall Street. Fiscal 1988 semiconductor sales were $3.1 billion, up from $2.5 billion in 1987, with profits up by more than $100 million, due in no small part to Junkins' decision to remain in the DRAM market.

But although the dogmatic Weber still boasts that TI "is the best in the West," this is a different company from the one that made the fateful decision to stay in the memory business. From sales and marketing to products and alliances, Junkins and Weber have spent the past four years changing just about every facet of the company.

And they came to one painful conclusion: The world doesn't revolve around Dallas anymore.

Change for the better

Gone is the old arrogance, and in its place is a belt-tightening, streamlined mentality that can actually poke fun at the days when TI believed it walked on water.

"We're not arrogant anymore," according to Weber a little wistfully. "You've got to be humble today."

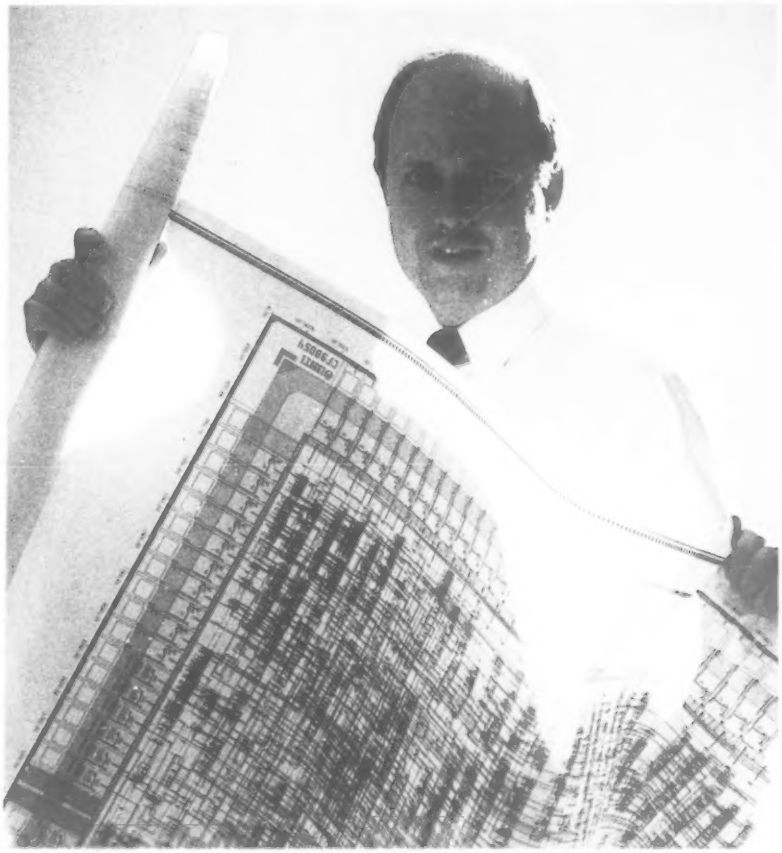
With that humility has come a completely new TI.

- Less is now more. The workforce has been cut by several thousand people since the hiring peak of 1984 to an estimated 27,900 employees worldwide. In fact, since 1987 the company has continued to cut back people, even though profits and revenue have increased dramatically.
- New noncommodity-oriented products are seen as the future of TI, from ASICs to application-specific processors.
- The company has gone worldwide. All semiconductor managers now operate on a worldwide product basis, rather than by region. Each group manager is responsible in a profit and loss fashion for his products worldwide.
- The "not invented here" syndrome, invented at TI, has died an inglorious death. Strategic alliances are the order of the day.
- And perhaps most importantly, TI employees for the first time are actually getting the counsel of their customers in designing products. According to executive vice president and group manager Walden "Wally" Rhines, "We spend twice as much time talking to our customers now as we used to."

It must be paying off. Graphics chip customer Larry Liang, president of Genoa Systems Inc. in Santa Clara, Calif., says that TI's customer

C. Thatcher

He hates to fly, but with operations everywhere from Miho, Japan, to Avezzano, Italy, TI's semiconductor group president Pat Weber takes a plane a week. "Today's technology businessman must be on a global time scale 24 hours a day," he says



Executive vice president Wally Rhines spearheaded TI's Sparc deal. With a host microprocessor on tap, he reckons, TI gets in early on a systems sale

Peter Poulides

service is really good now. Although Liang acknowledges that its software support is still a little weak, he says that overall, the company has improved in its dealings with customers. Spectrum Signal Processing Inc. marketing director Judy Bishop in Vancouver, B.C., adds, "TI is really easy to deal with now, once you get through the noise. They've become very responsive."

But one area that has not changed at TI is its belief in the critical importance of manufacturing for a worldwide semiconductor player. With 13 manufacturing operations in 26 countries worldwide, TI is in an enviable position.

For all the changing of its ways, TI remains ever conservative, heeding its traditional "go slow" Texan beliefs. "TI does not use a go-for-broke strategy," explains San Francisco-based Hambrecht & Quist Inc. analyst Millard Phelps. "For example, Intel Corp. likes to steer industry standards and industry software. If they miss, they are out of the market. TI is not inclined that way. They are not big risk takers."

But despite playing it safe, some obstacles remain. TI is still heavily dependent on commodity products that are facing the squeeze in 1989. Sales of DRAMs and transistor-transistor logic products represent more than half of the group's total sales in 1988, according to analysts' estimates. So, although TI has "changed for the better," says analyst Michael Gumport of New York City-based Drexel Burnham Lambert Inc., it will have to execute still more strategic changes in the future.

Strategies for change

Of all the changes Texas Instruments has made during its four-year metamorphosis, the most difficult ones have had to do with products.

TI was known for inventing every product it sold (or practically so), and the realization that "they can't do it all anymore," says analyst Phelps, cost the company quite a bit.

"But the world is changing so we had to change," explains Weber of TI's technology relationships with third parties.

Today, TI's plan is to capitalize on its strengths, the most obvious of which is DRAMs. But there are other, less noticeable areas as well. From digital signal processors through an entire range of market-specific processors, TI has been carving out a niche for itself that does not require having a "hit" host processor (although TI has a strategy for this, too). Other areas, such as standard cells, find TI with a No. 2 worldwide market share — not too bad for a company historically weak on the customer support and service side.

By going "with what we do best," Weber says, the company is then free to do business with the top companies in areas where TI is not so strong.

TI's deal last year with Sun Microsystems Inc. of Mountain View, Calif., and Cypress Semiconductor Corp. of San Jose for design and manufacturing rights to the Sparc RISC microprocessor signifies TI's new beyond-Dallas attitude.

It's not too difficult to figure out why Sun wanted to do the deal. "TI is an international manufacturer in every sense of the word," says Sun's technology marketing director Bill Keating. "TI can play a much more substantial role in the Sparc industry than NEC or Siemens AG [the recently announced partners of arch-competitor Mips Computer Systems Inc.] can."

This strategy is equally self-serving for TI. Frustrated over the years by the absence of a host microprocessor, TI executives were looking for a way to get in on the design cycle earlier, says one former manager in the group. A host microprocessor, with its attendant pull-through sales, was just the ticket.

"It's very important for us to work with customers on systems design," says Rhines, an easygoing sort who spearheaded the Sparc relationship. "By having a host microprocessor, you can deal with a systems designer on a total problem basis." In other words, Rhines says, with a host mi-

croprocessor in the sales portfolio, a company can get in on the sale early — and stay there.

But that is not to say that TI will take over the world with Sparc. It is just one of five Sparc vendors, and it appears to have taken a backseat to earlier players such as Cypress, which seems determined to drive the direction of the technology. Rhines says that TI will "begin to see some [revenue] effect from Sparc in 1989," but how much is questionable.

"TI's not going to get rich selling RISC," says Morgan, Stanley & Co. analyst Andrew Kessler in New York City.

Groping for the future

That's O.K. Rhines has plans to parlay the rest of his VLSI products group's efforts into millions. To fill in the gap left by a nonexistent host processor, Rhines put together a strategy to offer market-specific processors for areas such as local area networks, graphics, communications and signal processing. Although analysts don't credit this portion of the business with more than $200 million in sales in 1988 (excluding DSPs), this is an area TI is investing in heavily for growth, Rhines stresses.

Like processors, ASICs are a big thrust, although a one-time partnership with Intel has not brought much to the party. Even Rhines admits that the relationship "has not given us what we thought it would." But newer relationships with both Altera Corp. and hot new start-up Actel Corp. promise to give TI a nice piece of change in the programmable logic market. This is also an area where TI, with its commodity orientation, can shine.

Not surprisingly, Junkins and Weber have both made it clear that the future of TI lies in two areas — memories, and the so-called VLSI products group, which contains Sparc, application-specific processors such as DSPs, and ASICs. Currently, however, the largest percentage of the company's sales comes from the volume products group, which includes standard logic TTL products, linear products and military parts.

According to Wall Street firm Paine Webber Inc., TI's sales of TTL products alone accounted for more than $1 billion in 1988, a third of the total worldwide market. And although that is a declining market, it is still going strong for TI. Memory was the next largest, at just over $700 million, with peripherals products and linear products at $500 million and $450 million, respectively, in 1988.

TI readily admits TTL sales are on the wane. Says semiconductor vice president and volume products general manager Delbert Whittaker, "This is a declining market. There

Let's make a deal, says TI

TI's strategic alliances

1982	IBM
1985	National Semiconductor
1986	Philips/Signetics, DEC
1987	Hyundai, Linear Technology, Ericsson, Intel, NMB
1988	Altera, Sun, Cypress, Actel, Hitachi

Source: Texas Instruments Inc.

TI reshapes product lines along global responsibility

Pat Weber hates to fly.

But as president of Texas Instruments Inc.'s far-flung semiconductor group, he's on a plane every week.

"It's hell," he says, "but today's technology businessman must be on a global time scale 24 hours a day."

The key word here is global. TI has been operating in Japan and Europe since the 1960s, making it one of the more global semiconductor companies. But the biggest change over the past two years has been the company's restructuring of product lines along global responsibility. Rather than having a Japanese memory manager, a U.S. memory manager and a European memory manager, one worldwide manager is responsible, in a profit and loss fashion, for all memories. Weber says this structure eliminates regional competition, eases resource allocation dilemmas and streamlines the structure. Now one manager can rule the world.

About 60% of the company's semiconductor sales come from abroad, with Japan representing the largest portion, followed by Europe and the rest of the world, according to analysts. TI is the largest U.S. supplier in Japan, and has been for some years.

But Europe is important, too. "It's scary how much pressure we are getting from Europe," says semiconductor vice president and group manager Delbert Whittaker. "You've got to be in Europe, you've got to be in Asia. In today's market, if you're not global, you're out."

About 60% of TI's semiconductor sales come from abroad

So TI has structured its operations to take advantage of its global presence, and it is trying hard to break down international barriers of communications.

One example: the sister fabs of Miho, Japan, and Dallas do more than look and operate alike. Each employee has a twin or counterpart in the other fab, and often employees switch jobs and locales for some period of time in order to keep the communications open. There is also a fair amount of good-natured competition between the two.

A satellite communications network also helps, as do regular teleconference meetings for sales and marketing staffs. A huge network of terminals, 50,000 plus, links managers worldwide, and information on any operation can be found with a few keystrokes.

For other semiconductor companies, TI should be a model for going global, says Dataquest Inc. analyst Michael Boss. "TI has really set the pace in establishing worldwide operations," he says.

"TI is viewed as a local supplier wherever it is," adds Hambrecht & Quist Inc. technology analyst Millard Phelps. "That's more and more important. They are present in every market, and they speak in German, or Japanese, or whatever." □

Delbert Whittaker, TI's semiconductor vice president and volume products general manager: Declining products can yield profits through careful management

was a total available market of $3 billion in 1988, but that will drop somewhat in 1989. The days of the general purpose logic family are over."

TI's solution to that is twofold. First, the company is investing heavily in the future of logic, ASICs, with some analysts estimating TI to be putting 20% to 25% of its $600 million research and development budget into ASICs in 1989. Second, TI will not decrease its investment in TTL — on the contrary, there is still money to be made here, Whittaker says, pointing out that the market's $3 billion size makes it a huge opportunity.

The trick is staying ahead of the competition. Whittaker, a large, soft-spoken man with a long history at TI, believes that by careful management, declining products can yield profits. Over half of his general purpose logic business is outside of the United States, and the majority of it comes from older products from five to seven years ago. That means manufacturing is cheap and margins have been historically high.

And it's easy to target niches. Whittaker's strategy is to allow the customer to identify market niches, and then to move quickly to fill them. "It's all a matter of niche business now," according to Whittaker.

TI's other major niche business is in linear, where National Semiconductor Corp. offers some competition. TI, a world leader in linear, forged a relationship with aggressive start-up Linear Technology Corp. of Milpitas, Calif., for both design expertise and just plain manpower, according to Whittaker. With LTC in TI's court, Whittaker believes the company has some unbeatable advantages in linear, and it is one of the clear targets for high future growth. Investments are increasingly large here, and Whittaker says he has more business than he can handle reasonably. Leveraging TI's investment in a BiCMOS process has also helped in both linear and standard logic. That will be the future process technology for these products.

In fact, Whittaker says that in the past three years, there have been twice as many advanced linear processes developed as digital processes, which makes him believe the company has something to sell. "In linear, focus on the design know-how is in the past," he says. "Today, the emphasis is on process technology."

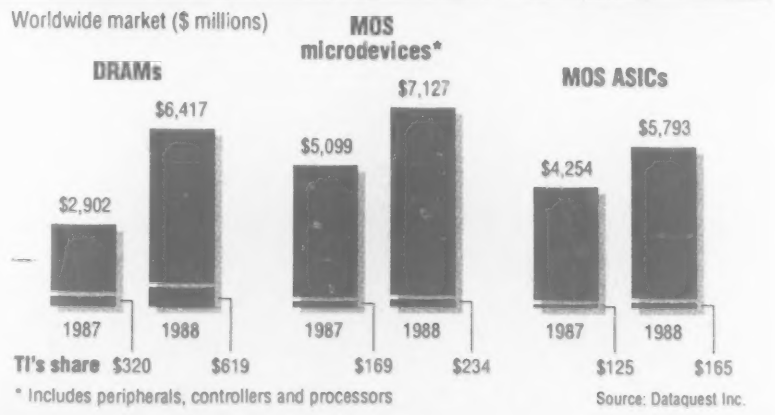
The DRAM dilemma

DRAMs, although not the largest portion of its business, are the most significant part of TI's manufacturing strategy. The sixth largest DRAM supplier in the world, TI has spent a substantial portion of its time and $500 million company-wide R&D budget over the past few years ramping up "sister" fab facilities in both Miho, Japan, and Dallas that are tailored to the new DRAM trench processes. With its recent announcement of the Avezzano, Italy, fab, TI will now tackle the 1-megabit and larger DRAM market with what it calls the "three brothers."

Combine those large investments with a steady revenue stream from memory royalty licenses, a research agreement with Hitachi Ltd. to explore the 16Mb DRAM manufacturing dilemma, and a leadership position in the embryonic 4Mb market, and it is clear that memory manufac-

Charles Thatcher

TI puts more faith in DRAMs



TI pioneers a market — and it pays

Texas Instruments Inc. should be envied its position in digital signal processors. Having grown the market from nothing, TI has more than a 60% share today — certainly enviable.

But the reality may not be quite so appealing. Ironically, TI is so dominant in DSP chips that "it can do nothing but lose market share," according to market researcher Forward Concepts Inc., Tempe, Ariz.

Forward Concepts estimates that in 1988, TI had $125 million in sales from general purpose DSPs, in a worldwide market estimated at around $215 million. That compares with TI's rival Motorola Inc., which "may do $10 million in 1988," according to Forward Concepts president Will Strauss. TI is also making money in DSPs now, while Motorola may have to wait another year or so, Strauss says.

Since Motorola has only been out with its part for less than two years, TI has a good running start on everyone else.

But there is some momentum going now in the market, and TI is going to have to work harder than ever to hold onto what it has built, analysts say. In addition to Motorola, competitors include AT&T and Analog Devices Inc.

But TI executives believe that old maxim, about imitation being the sincerest form of flattery, says group marketing manager Michael Haimes. "As the market has gotten very large, there have been a lot more competitors," Haimes notes, "so that just shows that TI was right."

As the first to really pioneer this market, TI is credited by customers and competitors for doing a number of things right. For example, several customers praise its aggressive university program, which put DSP development tools and software in the hands of 100 universities across the country, as instrumental in getting broad market acceptance. Haimes says TI also has over 80 active third parties to support customer requirements.

The challenge now, says Haimes, is to stay ahead of the competition and to continue to develop new products. With its four-year headstart, Haimes argues that TI will be able to stay on top since it has such a broad offering of products. "It is not just one homogeneous market anymore," he explains. "The market is splintering, and we can give customers different versions for new markets."

"TI has had more time, patience and muscle in the market," says Forward Concepts' Strauss. "They spent a lot of money conducting seminars and doing missionary work and now it has paid off." □

turing drives Texas Instruments.

That's fine with Weber.

"We are not talking just memory capacity here," Weber stresses. "We are talking advanced CMOS capacity, because I am going to be running logic processes in these memory fabs in the future."

The key is that every single product TI produces is leveraged from an advanced memory process. Older memory fabs are transitioned to logic and ASIC fabs, keeping all the processes on the cutting edge. From the company's linear ASIC product line to good old microprocessors, the memory process technology serves as a driver, and without it, Weber and Junkins believe TI could not assume a leadership position today.

Where does that leave the other major U.S. companies today that got out of the memory market when the getting was good? Out of luck, answers Weber, who says, "I would much rather be in the position we are in now than trying to get back into the memory business. This really separates the men from the boys."

With some analysts suggesting that between 25% and 30% of TI's revenue comes from memories and their royalties and a much higher percentage of the group's profit, TI is heavily dependent on the memory market for its continued growth. And perhaps, as prices decline, this is where an old-line commodity player like TI will shine. But some analysts aren't sure.

"They're not going to make a lot more money in DRAMs" argues San Francisco-based Robertson, Coleman & Stephens analyst Eric Jansen, who has rated TI's stock a "hold." "There will be a decline in prices down to less than $10 per 1Mb by the fourth quarter [compared with $15 to $18 in the first quarter] and that is going to affect them."

"DRAMs are going to be a problem in terms of managing profit and loss," states Morgan, Stanley's Kessler. "The [downward] price curves on DRAMs this year are going to be more than the average 30%."

An even gloomier view comes from a report from S.G. Warburg & Co. Inc. in San Francisco, where analyst Eli Sayegh argues that the drop in DRAM prices, the drop-off in royalty revenue and the easing of the shortage will combine to leave TI in a difficult profits position. Sayegh rates the stock a "sell."

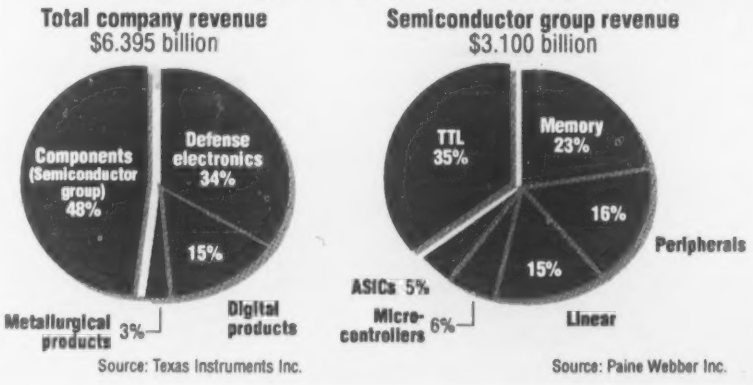
Weber, who dismisses analyst forecasts as too short term to be listened to, does acknowledge the downward pricing pressure on memories, but says Texas Instruments is well positioned.

"Pricing is going to return to the same horrible experience it was before," according to Weber. "But we are bringing our cost plans down the learning curve in a manner that is consistent with the pricing decreases."

TI anticipates that 1Mb DRAMs

At TI, chips are big — and TTL chips biggest

TI's sales for fiscal year ending December 31, 1988 ($ millions)



Source: Texas Instruments Inc.

Source: Paine Webber Inc.

will be at less than $10 by the fourth quarter, Weber says, but notes that, "We don't control the costs here. The Japanese do."

Meanwhile, demand may not be as weak as some are expecting. Texas Instrument's worldwide memory manager Robert England argues memory is a growing percentage of the total market every year (more than 30% in 1988), and that new applications, such as memory-hungry laser printers and faxes, will partially offset any downturn in PC demand.

When looking at growth in 1989, TI executives remain rather quiet. Highly conservative management ideals keep forecasting to a minimum, and the only thing clear is that 1989 won't be a banner year like 1988. In fact, most analysts are suggesting TI will grow 5% to 7% company-wide this year.

"If they make money at all this year they'll be doing very well," concludes Hambrecht & Quist's Phelps.

In any case, Junkins and Weber seem comfortable facing the worst case scenario, even to the extent of downplaying Texas Instrument's recent successes.

For 1989, Weber will not be relying on any miracle cure.

"It's going to take the industry a long time to recover [from the 1985 to 1986 period]," he offers. "We've got a long way to go before we can make up for the billions we lost" on the memory market. □

Protecting the hard to protect: TI makes its patents pay

Staying in the memory business had its price.

For Jerry Junkins, Texas Instruments Inc. chairman, the price was changing the rules.

"In the depths of the dumping," he says, "we took a look at our strategy and realized that the world had changed.

"It was tough, if not impossible, for us to receive the return we needed to have on our products in order to reinvest in the business, so we had to change the rules," he explains. "We had to have greater return from the marketplace on our royalties and we were prepared to enforce it with legal means."

And the rest was history. With a "take no prisoners" attitude, TI has aggressively pursued those it felt infringed, and has been perhaps the most successful company in wresting real dollars from patent infringers. Over the past two years, TI has reaped about $315 million from patent infringers. All this goes straight to the bottom line.

Senior vice president and assistant general counsel Mel Sharp oversees TI's thrust into the murky world of patent infringement. And Texas Instruments has certainly been on a roll here.

In the past three years, TI has doubled its number of patent filings, as well as greatly increasing its offshore filings. And it is filing on a broad number of things, Sharp says. "Ten percent to 15% of our filings are in the 'whacko' category," he explains. "We can never tell which are the jewels when we file. Looking back today, 25% of the time we're right."

Patent filing alone isn't enough.

Charles Thatcher

Mel Sharp, TI's corporate counsel: "It's hard to get international companies to agree to value intellectual property if U.S. companies won't"

TI "needs a credible threat of an injunction to gain value in the market," Sharp stresses. And it has a credible threat. The company is currently involved in over 20 "discussions" of patent infringement, "as both plaintiff and defendant," he says. At the very least, TI has proven it is willing to go all the way to court or the International Trade Commission, if need be.

Although TI's most memorable — and profitable — successes have been offshore, Sharp believes that enforcement must begin at home. Witness the recent suit against memory upstart Micron Technology Inc. over DRAM patents. "It's hard to get international companies to agree to value intellectual property if U.S. companies won't," Sharp says.

To support all this activity, Sharp has increased his total staff to 60, and added a seven-lawyer contingent in Japan. "Trying to deal with the Japanese language as an American is difficult," he admits. Having a staff of Japanese attorneys "makes a lot of difference."

As to when the litigious activity will slow down, Sharp is not too optimistic. "I think it will take another five years of aggressive action on the part of TI and others before the message gets through." □

Reliability spells edge in competitive drive market

Disk drive suppliers are bucking reliability odds with enhanced design and quality control programs — often exceeding "plug-and-play" goals

BY DWIGHT B. DAVIS

The electronics industry as a whole spends a great deal of money and effort in the dual pursuit of making products both smaller and more powerful. Hard disk drive manufacturers are not immune to this preoccupation, as evidenced by the current spate of 3.5-inch-diameter disk products that store as much as 200 megabytes of data, and 5.25-inch drives that hold more than 1 gigabyte.

But packing more and more data onto a disk's surface increases the difficulty of ensuring that the electromechanical drive will operate reliably. Ironically, the importance of reliable operation increases with the disk's capacity, since the failure of a several hundred megabyte drive is much more critical than the crash of a personal computer's 20MB disk.

Fortunately, drive suppliers generally have been able to buck the reliability odds: the manufacturers have accomplished major mean-time-between-failure (MTBF) improvements in each successive generation of their products.

"In our first year or two, our products had mean time between failures of about 11,000 hours," says Steve Kitrosser, executive vice president for operations at Maxtor Corp., San Jose, which went public in 1985. "In successive years the MTBF climbed to 16,000, then to 20,000, and today our products offer MTBF ratings of 30,000 to 40,000 hours or better."

A number of factors have contributed to this industry-wide trend, including design improvements that reduce component counts and simplify manufacturing, as well as the development of more rigorous testing and quality-control programs. Driving this trend, in large part, have been OEM customers that have placed a premium on high product quality as well as on competitive price and performance ratings.

"OEMs are putting extreme pressure on us to deliver drives that work reliably right out of the box," says Ray Miller, vice president for quality and reliability at Quantum Corp. of Milpitas, Calif. Because Quantum has devoted so much attention to meeting this demand, he says, many of its customers have been able to initiate "ship-to-stock" programs, in which the OEMs dispense with their own testing of incoming products.

The operational success rate of the shipped drives — usually referred to as the "plug-and-play" rate — is measured by most vendors at the end of the OEMs' system integration processes, although some may quote simple out-of-box conformance to specifications. Miller says Quantum's drive specifications call for a post-integration plug-and-play rate of 99.5%, and claims that the company's drives often exceed that goal.

Carter O'Brien, director of marketing at market leader Seagate Technology, San Jose, which attained revenue of about $1.3 billion for the fiscal year that ended June 30, 1988, says the "comfort level" for most OEMs is a plug-and-play failure rate of no greater than 2%. "A failure rate of only 1% is great," he says, "whereas a rate in the 10% range would be disastrous." For his part, Dan Gust, a division manager at Mini-Scribe Corp., Longmont, Colo., says he would consider even a 2% to 3% failure rate unacceptable.

"Drive vendors should, in theory, be able to charge a premium price for products that allow OEMs to establish ship-to-stock programs," says Phil Devin, a senior industry analyst with San Jose-based Dataquest Inc. In reality, he says, many OEMs still rate product quality third in importance behind the cost per megabyte of a

Paul Shambroom

Bill Miller, president and CEO of Imprimis: "Our management has attached great significance to achieving quality"

drive and its performance.

Nevertheless, Devin notes, the quality of competitive vendors' drives constitutes an important differentiating factor in the marketplace. Quantum's Miller agrees, claiming, "We've gained a number of large OEMs as customers because of our reputation for producing reliable products."

In the highly competitive hard disk drive marketplace, such an edge can prove critical. Much of the industry found itself engaged in price cutting last year, especially in the high-volume 5.25-inch drive sector.

In that market, suppliers, led by Seagate, ramped up their 1988 production of drives based on an expected boom in the growth of personal computer sales. The actual growth fell short of the projections and, at the same time, many PC manufacturers switched from the standard 5.25-inch drives to the newer 3.5-inch models.

The resulting overcapacity caused an industry-wide earnings slump, as drive vendors cut prices and retooled their manufacturing facilities to meet the demand for compact drives. Although worldwide revenue is forecast to rise 20.7% in 1989 over 1988, according to Jim Porter, president of Disk/Trend Inc., a Mountain View, Calif., market research firm, earnings at a number of the major suppliers are expected to suffer because of price cutting brought on by overcapacity and competition from market share.

At Maxtor, for example, third quarter 1989 revenue, ended Dec. 25, 1988, was $91.4 million, a 23% increase over the $74.1 million figure for the same period in the previous year. However, Maxtor's net income of $767,000 for the third quarter 1989 compares with $5.15 million the previous year.

"In a period of oversupply with all of the competitive drives in the same capacity range, product quality became the most important differentiator," says Maxtor's Kitrosser.

Reworking extremely costly

Aside from landing contracts, most drive vendors recognize that producing quality products helps them in other ways. "We want to achieve high first-time yields because reworking is extremely costly," explains Quantum's Miller.

Should flawed products slip through a vendor's hands and its OEM's testing procedures and into the field, the economic consequences can be immense. One such installed "time bomb" occurred with Control Data Corp.'s FSD II class of 9-inch drives in the mid-1980s. These drives suffered from premature wear of the disk's surface following repeated head contacts.

"Every vendor's FSD II class drives had significant problems," according to Bill Miller, president and CEO of Imprimis Technology Inc., Minnetonka, Minn., who explains that the 9-inch drives represented a jump in technology from their 14-inch predecessors of similar capacity. Imprimis was established as a wholly

Seagate's marketing director, Carter O'Brien: Other companies can take technology risks more easily

owned subsidiary by Control Data Corp. in September 1988, and supplies its parent company as well as the OEM marketplace.

Control Data did a commendable job of backing up its products, according to Mike Casey, director of storage industry research for market research firm InfoCorp, but at a tremendous cost. He quotes estimates that the drive snafu cost the company as much as $50 million to rectify. Imprimis' Miller will only say that "we spent millions and millions of dollars replacing drives and correcting the problem."

"Partially because of the FSD II experience," he continues, "we've established considerably more elaborate testing and quality control procedures."

Imprimis and its competitors have established a variety of programs and procedures to promote employee attention to quality. Maxtor, for example, provides all of its employees, from management on down, with a profit sharing plan.

The nature of the disk drive industry, however, is not such that a vendor's attention to quality control can end in house. Although some vendors such as Seagate and Imprimis are fairly vertically integrated, most U.S. suppliers rely heavily upon third-party sources for most components, performing only the initial design, the final assembly and the testing themselves.

Those that rely more heavily upon outside suppliers counter that they are able to exploit each supplier's expertise in component manufacture. This approach works well today, "because our supplier base is much more mature than it was several years ago, and their products are much more reliable," says Kitrosser at Maxtor.

Limiting third-party firms

Maxtor works closely with its suppliers from an early stage in each product's development, Kitrosser says, and has been limiting the number of these third-party firms in order to exercise better quality control. "Five years ago we were producing five to 10 drives a day and we had 13 different suppliers," he says. "Today we're producing thousands of drives daily, but we have only three major suppliers."

Another factor in the pursuit of reliability involves the diameter of the disk, or its form factor. Imprimis differs from other U.S. drive makers in that it produces hard disks ranging in size from 3.5 inches to 14 inches. "We offer the broadest product range of any U.S. drive company," president Miller says, while noting that different size drives introduce different reliability concerns.

"For example," Miller contends, "on a 14-inch drive, when the head hits the disk surface it has a greater physical impact than a smaller drive's head crash." However, this impact difference is due in part to the fact that, for a given areal data density, a large disk's head flies higher above the disk platter's surface than the head of its smaller

Liane Enkelis

counterpart, according to Miller.

Smaller drives require higher packing densities of components than larger drives, he notes. Such distinctions require that vendors establish appropriate specifications and testing programs for each form factor.

Even more important from a reliability perspective than a drive's form factor, however, is the density of the data packed onto the disk's surface. As the density increases, the size of an individual bit cell decreases, as does the size of any contaminant that could cause a reading problem. The magnetic signal of each bit is reduced, and the read/write head consequently must fly closer — on the order of 10 to 17 microinches — to the rotating disk surface.

These tightening parameters inevitably up the potential of head crashes and other malfunctions. As a result, disk vendors find themselves in a situation of balancing the demand for higher capacity products with their ability to design and manufacture drives of adequate reliability.

"We often get 'dinged' for not being technology leaders," says Seagate's O'Brien, "but we can't risk it. With our high production volumes it would be catastrophic if a product had a short field life. Others can take the technology risks more easily."

Seagate's highest capacity 3.5-inch drive holds 83.9 formatted megabytes and its densest 5.25-inch product has a 168.5 formatted megabyte capacity. Vendors like Maxtor, Imprimis, Connor Peripherals Inc. and Areal Technology Inc. offer 200MB (unformatted) 3.5-inch drives; Imprimis and Micropolis have announced 5.25-inch products that store 1.2 gigabytes of unformatted data.

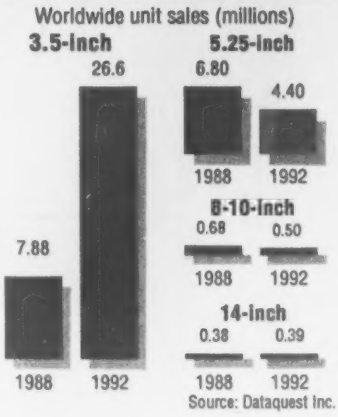
Maxtor's Kitrosser admits "There is no doubt that squeezing more and more data onto a drive makes the maintenance of quality more difficult," but he says Maxtor's understanding of how to attain such quality is well ahead of the level of products it is now producing.

"At the leading edge of technology, there will always be some increased level of risk," concurs Miller at Imprimis, "but we don't get out on the ragged edge. We go only as far as the technology will allow us to reliably go."

Most in the industry agree that factors other than pushing the technology limits are most likely to cause drive failures. "Cost cutting measures on the part of the manufacturers are more likely to cause quality problems than higher densities," says Dataquest's Devin.

Miller at Quantum says some disk drive manufacturers place pressure on their suppliers for rapid delivery of components at the expense of quality. "A supplier might normally require 12 weeks to deliver a shipment, and the disk drive house pushes for two-week delivery," he says. "It's when the manufacturer tries to exceed the capacity of its suppliers' operations that problems occur." □

Hard disk drive market



Source: Dataquest Inc.

Quantum banks on TQC — total quality control

Because the disk drive industry as a whole has an impressive quality record, even small differences in the competitors' product failure rates can make or break OEM deals. One company that has been particularly successful in landing contracts because of the quality and reliability of its drives, many analysts agree, is Quantum Corp.

"We have a Total Quality Control program that extends throughout the entire company," explains Ray Miller, vice president for quality and reliability. "The TQC program encompasses every department, including sales, marketing and accounting, as well as design, engineering and manufacturing."

Also, the design process includes three types of testing. Engineering verification testing and analysis verify the ability of the design to meet the customer's requirements and specifications. Design verification testing ensures that the drive will meet the specifications under all environmental conditions.

Finally, design maturity testing is performed prior to volume production to ensure that all aspects of the drive's operation, including its demonstrated MTBF, are within the acceptable range.

Quantum's manufacturing processes are equally rigorous, Miller says, and include constant testing, audits and functional reviews. The long-term reliability of the finished drives is verified through real-time sampling and testing that includes the continuous running of drives for four weeks and a total sample of 130,000 operational hours per month.

Quantum's ace in the hole, however, may be its partnership with Matsushita Kotobuki Electronics, which performs the bulk of the final assembly for Quantum. Furthermore, Miller notes that in the 3.5-inch sector, Quantum has shipped tens of thousands of drives, but fewer than 1,000 have been returned for rework or replacement.

"That level of quality is unheard of in the Seagate operation, which nevertheless offers good value for price in its marketplace," says Phil Devin, senior industry analyst at Dataquest Inc. He gives the Matsushita facility much of the credit for this success rate and notes, "Visitors to the Matsushita plant are often astonished to discover that the factory doesn't even have a rework area."

Miller credits Quantum's demonstrated product quality with tipping the balance toward the company in the competition for several large OEM contracts. In 1988, for example, the company signed major deals for its 3.5-inch drives with Tandy Corp., Commodore Business Machines Inc. and, most importantly, Apple Computer Inc. The $70 million Apple order followed an earlier Quantum contract with Apple to supply the PC vendor with 5.25-inch drives. □

Telecommunications controversy Down Under

Australia's telecommunications industry is undergoing deregulation, well, sort of . . . sparking controversy and cries of unfair play

BY CRAIG ADDISON

A string of commercial joint ventures at home has signaled a new era for Telecom Australia, the $6.1 billion national telecommunications carrier. Like AT&T several years ago, Telecom Australia will soon lose its government-blessed role as the monitoring body of the country's telecommunications industry. Under the newly deregulated market, Telecom Australia is free to compete in value-added network (VAN) products and services.

But by entering into commercial deals before it hands over its regulatory duties, the monopoly carrier has been accused of unfair play. [Editor's note: Telecom Australia is still the official telecommunications umpire, at least until the federal government establishes the independent Australian Telecommunications Authority (Austel), which won't be fully operational for at least another year.] And even when it does hand over umpiring duties, Telecom Australia will still own and operate the country's backbone communications network. Critics argue that this will give Telecom Australia considerable advantage over other competitors in the emerging VAN market, estimated at $77 million last year, according to Paul Budde Communications Pty. Ltd. of Sydney.

So far, Telecom Australia has invested $56 million in almost a dozen joint ventures, including two recent controversial deals with foreigners. One joint venture that caused a storm was the $11 million agreement struck with Hewlett-Packard Australia Ltd., which came under the scrutiny of the Australian Trade Practices Commission. The deal was allowed to go through, allowing Telecom Australia to offer communications and computer solutions, based on HP's products, to major corporate customers.

There were more cries of protest when Telecom Australia joined forces with Fujitsu Ltd.'s Australian subsidiary to design and manufacture ISDN PABX systems for local and international users. This deal effectively blocked out Telecom Australia's previous PABX suppliers — Siemens AG and NEC Corp. — and, perhaps most importantly, provided Telecom Australia with access to Fujitsu Australia's new $31 million manufacturing facility in Melbourne, Victoria.

Telecom Australia's recent joint ventures

Joint venture (year established)	Shareholders	Telecom investment
Advanced Network Management (1988)	Telecom Australia (60%) Systems Reliability (UK) (40%)	$350,000
Aussat (1984)	Telecom Australia (25%) Australian Government (75%)	$22 million
Telecom Hewlett-Packard (1988)	Telecom Australia (50%) Hewlett-Packard (US) (50%)	$11 million
Information Switching Technology (1988)	Telecom Australia (60%) Fujitsu (Japan) (40%)	$1.7 million
Natsoft Communications (1988)	Telecom Australia (50%) Merlin Communications (28%) Praxa (22%)	NA
QPSX Communications (1987)	Telecom Australia (60%) University of Western Australia (40%)	$5.4 million
Telecom-Messagetech (1988)	Telecom Australia (51%) Voicecall (49%)	$3.2 million
Telecom Technologies (1987)	Telecom Australia (50%) Exicom (50%)	$8 million

Conversion rate: Australian $1.14 = U.S. $1

Source: Telecom Australia

A conflict of interest?

The HP and Fujitsu partnerships raised conflict-of-interest concerns by the Australian Telecommunications User's Group (ATUG). Executive director Wally Rothwell points out that while Telecom Australia is legitimately in the carrier business and has approval to compete in VAN services, many of the company's joint ventures are computer and communications manufacturing operations. Telecom Australia wields enormous buying clout and could favor equipment and services from its joint venture partners, at the expense of other suppliers, maintains the ATUG.

Telecom Australia's senior executives counter that joint ventures are a necessary strategy for survival and they refute claims that their control of the telecommunications network will result in an anticompetitive environment. Certainly Telecom Australia, with sales of $6.1 billion and a profit of $682 million last year, has the financial muscle to continue its joint venture activities. □

[Australian $1.14 = U.S. $1]

Military tragedies spur call to simulator firms

Accidents due to low-level NATO training missions mean West Germany is set to become the proving ground for next-generation flight simulators

BY BRUCE C.P. RAYNER

The West Germans have had enough. In the last year, more than 100 people, mostly German civilians, have been killed as a result of NATO air accidents. The worst accident was last August, when three Italian fighter jets collided at an air show at the U.S. Air Force Base in Ramstein, West Germany, killing 70 people. Not as disastrous but equally disturbing was a French Mirage F-1 accident last April near two nuclear power plants just 50 miles from Munich. And in February, six U.S. F-16s, based at Ramstein, came dangerously close to six passenger airliners over Frankfurt airport.

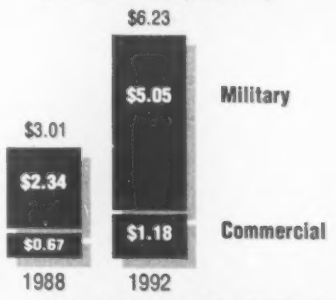
The central problem is low-level flight training. NATO insists its pilots need low-level training in Germany because this is where World War III would be waged. But critics counter that the cost in terms of lives and property has escalated to an unacceptable level. The alternatives are to conduct low-level flight sorties in remote areas — Northern Canada, Utah and Sardinia are all options — and to use high-technology flight simulators.

Political heat is spilling over into NATO troop movements too, the complaint being environmental damage. The 1989 U.S. Reforger troop exercises (Return of Forces to Germany) that were to take place in September, have been postponed until early 1990. The U.S. Department of Defense denies that politics had anything to do with the decision, claiming that it is simply a part of the new "training smart" philosophy at the DOD. However, the new philosophy conveniently involves using more simulators and less troops. All this is good news for simulator companies. What was a $2.3 billion worldwide military simulator market in 1988 is expected to grow at a 23% annual rate to $5 billion by 1992, forecasts Mark Lawrence, a technology analyst with Prudential-Bache Securities Inc. in Toronto and a simulator market watcher. Military training budgets will post a 35% growth rate while hardware expenditures will increase by 18% over the four-year period, he predicts. The United States accounts for about 75% of the total military simulation market.

Already there are signs of new business as a result of the political pressure. The German Ministry of Defense (MOD) has contracted with CAE Electronics GmbH of Stolberg, West Germany, a division of CAE Industries Ltd. of Toronto, to supply prototype low-level flight simulation capabilities for the German Air Force's Tornado fighter. Evans & Sutherland Computer Corp. of Salt Lake City is CAE's primary subcontractor and will supply the visual system image generator.

Simulation market

Worldwide sales ($ billions)



Source: Prudential-Bache Securities Inc.

The U.S. accounts for about 75% of the total military simulation market

CAE has the largest military simulator market share in the world, followed by Hughes Aircraft Co. and Loral Corp., in that order, says Lawrence. Other major players include The Boeing Co., Evans & Sutherland, General Electric Co., IBM and McDonnell Douglas Corp.

The prototype phase of the CAE contract is valued at about $50 million, with evaluation expected to be completed by spring of 1991. If it meets with the MOD's approval, an order will be put out for seven more units with a price tag of about $300 million. This second phase involves modifying the existing seven Tornado simulators that the German Air Force uses so it can perform low-level flight training. Delivery is expected sometime in 1992 and 1993.

Because of such lucrative business, simulator companies on both sides of the Atlantic are consolidating their market positions through international acquisitions and teaming arrangements. The competition is expected to intensify as follow-on contracts to the Tornado materialize in the 1990s, pundits say. Already, the Germans are said to be in the market for an F-4 simulator and other NATO allies are watching closely. Even the United States is making overtures.

Last November, Brig. Gen. Bruce Lotzbire, the assistant director of operations for the U.S. Air Force in Europe (USAFE), took a swing through a few North American companies where simulators are made to see if they could be used for low-level flight training in Europe. But USAFE has so far concluded that available visual systems cannot currently replicate low-level flying at the tactical air speeds required for training, a USAFE spokesman says. However, "USAFE has been in contact with the German Armament Division in

charge of testing the Tornado flight simulator prototype, and USAFE participation in the evaluation is a possibility," he adds.

If the political pressure in Germany spreads to other countries, simulator budgets will rise. And that $5 billion market figure for 1992 might end up being too conservative, says analyst Lawrence. What is more, Europe's relations with the Soviets are improving and NATO defense budgets will fall in the 1990s. In general, budget cuts bode well for simulators: it is cheaper to fly a mock-up of a Mirage or a B-1 than to take the real thing out on a training mission.

Other factors are playing on the European simulator industry as well. However, foreign defense firms are looking to increase their European business before intra-European trade barriers come down in 1992. Meanwhile, there has been speculation that a few of the big European defense firms — British Aerospace Plc, Messerschmitt - Boelkow - Blohm GmbH and Thomson-CSF — have discussed forming a stronger, more cooperative European simulation industry. Consequently, competition for simulators for new platforms like the European Fighter Aircraft and the French Rafale fighter aircraft will be stiff in the mid-1990s.

"In order for U.S. simulation companies to make a dent in Europe, they must team with European companies," says Robert Reed, executive director of the newly formed National Training Systems Association. Reed is a retired U.S. Air Force general, formerly the chief of staff at Supreme Headquarters, Allied Powers Europe. Major areas of U.S. contribution include processing equipment, imagery projection and digital land mass technology, according to Reed.

Military training budgets should post a 35% growth rate

Complement, not substitute

But can all this whiz-bang state-of-the-art technology *really* satisfy low-level flight testing requirements? According to most experts: no, it cannot. Simulators might complement but will never substitute for the real thing, they say. There is even the fear of negative training from simulators — a condition whereby pilots learn tricks in the simulators that, if used in the cockpit, might prove fatal. Also, air forces both in the United States and Europe fear that if they start budgeting for simulators, their planes will be taken away.

Former Navy test pilot Chuck Myers of Aerocounsel Inc. of Arlington, Va., insists simulators are inappropriate for training. "If you don't go out in the plane and do it," says Myers, "sitting in an electronic box won't do it." Myers recommends using cheaper planes for low-level training missions. But critics say cheap planes can hit buildings and nuclear power plants just as easily as expensive ones.

Still, simulators have their advantages. They can teach weapons delivery, instrument practice and emergency controls. These exercises are either too expensive to do in the plane or too dangerous to attempt. What is more, simulators can be used 24 hours a day.

There have been quantum jumps in the technology for visual systems in the past few years. At the Human Resources Laboratory (HRL) at Williams Air Force Base in Mesa, Ariz., Harold Geltmacher, chief of technology development at the operations

Marty Braun

training division, has been working on some of the stickier problems of simulation.

The HRL focuses on the technology to fill the gaps in the equipment currently available from contractors. Most of Geltmacher's work to date has centered around computer image generation and display systems — that is, how to create and project realistic images.

Some of the solutions that Geltmacher and his team worked on are the very ones the German air force plans to buy. In fact, the Germans will be the first to use this equipment for more than just R&D. The equipment includes a CAE-supplied fiber-optic helmet mounted display unit that gives the pilot a detailed "area of interest" picture through the eyepiece. That means that the resolution of the image is best at the center of the image, where the pilot's eye is focused, but deteriorates at the edges.

According to Jack Derwett, manager of General Dynamics' R&D flight simulation laboratory in Fort Worth, Texas, the area-of-interest simulator is "the way of the future." And what the Germans are buying will be one of the most sophisticated simulation systems in the world.

"The technology is well advanced, but it is not complete," adds Peter Gramson, the new business manager for military simulation at British-based Rediffusion Simulation Inc., a Hughes Aircraft firm. He estimates that the current state-of-the-art simulator is about 70% to 80% of what is needed.

While most of today's research and development is going into improving the fidelity of the computer-generated image, other areas have lagged behind, Gramson comments. For instance, understanding the psychology of how and why pilots respond to certain stimuli in the cockpit, called queues, is still an area that requires attention. At the HRL, says Geltmacher, understanding queues is a major area of interest.

Acquisitions and teaming

Not surprisingly, international acquisitions and teaming arrangements have been running rampant. Heavyweights such as British Aerospace, CAE Industries and Hughes Aircraft have all made international simulation acquisitions in the last year. Others have gone the teaming route. For instance, General Electric, a leader in vision systems with its CompuScene IV system, has teamed with Germany's Messerschmitt-Boelkow-Blohm.

One cause of the acquisition binge is the demand by the military — mainly the U.S. Department of Defense — for total training systems, that is, delivery of all services necessary for training a pilot. These include simulators, training manuals, courses and testing. The idea is for the contractor to supply a totally trained and guaranteed pilot. At present, CAE is the only company that offers this total training option.

One cause of the acquisition binge is the military's demand for total training systems

Although most of the big simulation players have changed hands, a few important acquisition question marks remain. One is Evans & Sutherland, one of the two leading international suppliers of top-of-the-line vision systems, the other being GE. However, it is Evans & Sutherland's ESIG 1000 systems that the Germans will be purchasing.

The $130 million company would be a natural fit for any of the big aerospace companies involved in simulation or interested in entering the market, say analysts. Of course, that includes most of the world class defense players.

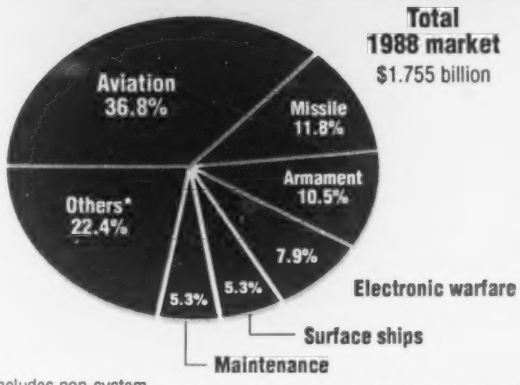
Even though Evans & Sutherland is not currently on the market, its stock is widely held and its technology is in hot demand. Likely U.S. suitors include Loral and any one of the major air frame makers including Boeing, Hughes or McDonnell Douglas, says Prudential-Bache's Lawrence.

Boeing supplies the Air Force with B-1 simulators; Loral supplies an F-15E trainer; and McDonnell Douglas supplies simulators for the F-14D and the A-6F. Hughes has its fingers in a lot of pies. Last April, it paid $270 million for Rediffusion Simulation, which supplies about 40% of Britain's military simulator contracts, and late last year it paid about $100 million for Honeywell Inc.'s Training and Control Systems Division.

Even CAE Industries might be interested in Evans and Sutherland. The $750 million company has divisions in Britain and West Germany and last year entered the U.S. military market by purchasing four Link simulation and training divisions from Singer Co. for $550 million. Although Link Flight Simulation, one of the U.S. divisions, has its own vision system, experts say the Evans & Sutherland ESIG 1000 technology is more advanced.

Foreigners would be interested in Evans & Sutherland, too: Thomson-CSF, the French military electronics giant, is one potential suitor. Last year, Thomson lost out to Hughes in its purchase of Rediffusion and withdrew its offer for Link-Miles, a Singer division still owned by Paul Bilzerian, the corporate raider who took control of Singer early last year. However, pundits say the Pentagon would not look favorably on foreign ownership of such advanced technology. But then the Department of Defense did not complain when CAE Industries bought Link. □

U.S. military simulation spending



* Includes non-system specific training devices

Sources: Frost and Sullivan Inc., Prudential-Bache Securities Inc., ELECTRONIC BUSINESS

A vision is fulfilled: VSATs flourish — finally

The hype and hope years have ended. VSAT applications are materializing and prices are falling, to the delight of wide area datacommunications users

BY ANNE KNOWLES

It has taken longer than expected, but the market for very small aperture terminals, or VSATs, is finally living up to its predicted potential. The technology — touted as the answer to corporate America's wide area datacommunications needs since early in the decade — has had its kinks ironed out, say VSAT manufacturers and service providers. Costs have dropped and more applications have materialized. Now, the small satellite earth stations are popping up everywhere.

VSATs, small, software-intensive earth stations designed primarily for data and video communications, are easily and quickly installed. They allow users to reconfigure their wide area communications networks more quickly than a network based on phone lines. That gives the user greater control.

The U.S. VSAT market, which accounts for the lion's share of today's worldwide market, more than doubled last year. The U.S. market grew from $63.2 million in 1987 to $151.4 million in 1988, according to Dataquest Inc., a market research firm in San Jose. This year, the market should hit $193.3 million, Dataquest projects, and continue to register about 40% compound annual growth for the next four years, until it reaches an estimated $493.3 million in 1992.

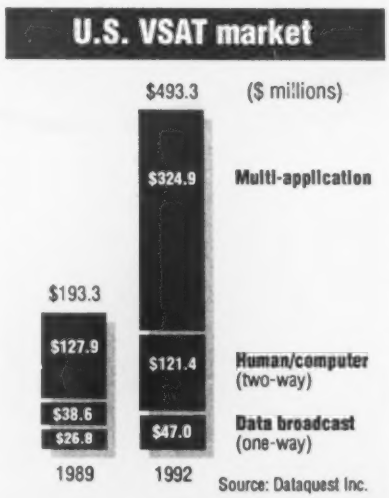
There are between 10,000 and 13,000 VSATs currently installed worldwide, says Frank Connors, president and CEO of Satellite Technology Management Inc. (STM), a VSAT equipment supplier in Costa Mesa, Calif. But there are between 25,000 and 30,000 VSATs on order throughout the industry, Connors says. That is about two to three times the installed base.

Manufacturers originally marketed VSAT networks as a cost-effective, flexible alternative communications media for remote location communications. The reality, however, was neither cost effective nor flexible.

Early systems inflexible

Combining the satellite-based technology with existing packet-switching technology also presented more hurdles than early vendors owned up to. That led not only to delays, says Roberta Wiggins, senior analyst with The Yankee Group in Boston, but it also destroyed user confidence in VSAT technology. In addition, more mundane problems, such as having to secure landlord permission to install rooftop VSATs, led to further delays and frustrations.

"Early systems met only one or two specific applications," says Bill Hogan, network systems group marketing manager at Scientific-Atlanta Inc., a VSAT manufacturer in Atlanta. "They were very inflexible and the costs were high. Early companies sold on a lot of promises and it took a long time to work through the problems." But in the last year, says Hogan, "the bugs have been worked out."



The U.S. VSAT market should register 40% annual growth over the next 4 years

Prices have also dropped. Three to four years ago, says Hogan, a remote VSAT, equipment only, cost about $15,000. Today, that same system, says Hogan, is priced between $10,000 and $11,000. Most manufacturers and analysts agree that VSATs now cost between 20% to 50% less than the same application run across leased phone lines. Most participants also agree prices are beginning to stabilize and will drop less dramatically in the coming years.

Increasingly, VSATs are replacing existing phone lines in major metropolitan areas. "Almost every VSAT out there," says R. Gary Mesch, vice president for marketing and sales at Nova-Net Communications Inc., a turnkey supplier of VSAT networks in Englewood, Colo., "is installed to replace leased lines."

Subsequent large contracts also have rekindled user confidence. Chrysler Corp., for example, has 6,000 VSATs installed and buys them from Hughes Communications Inc., a VSAT supplier owned by Chrysler competitor General Motors Corp. K mart Corp., the retailer, was an early adherent to VSAT technology that, despite snafus, continued its contract with GTE Spacenet, the satellite communications division of GTE Corp., for a private data and video network for its 2,100 stores.

While the market has been steadily growing, the industry itself has been in flux. Players have come and gone. Some companies dropped out of the market after making promises they

couldn't keep, says Philip Arcoria, marketing manager for NEC America Inc.'s satellite communications systems division. Other companies have spun off. Vitalink Communications Corp. in Fremont, Calif., for example, spun off its VSAT division, now called Vitacom Corp., in order to concentrate on its wide area and local area network business, says Bruce Bell, vice president for operations at the employee and venture funded Vitacom.

But most of the name changes have been because of acquisitions. Early entrants in the market were start-ups that could not survive the large capital investments alone, says Yankee Group's Wiggins, and thus began looking for buyers. Larger corporations, looking for existing technology, bought their way into the market.

Contel Corp., Atlanta, bought American Satellite Co., turned it into its network and satellite division called Contel ASC, which in turn acquired Equatorial Communications Co., making Contel ASC the largest VSAT supplier. Hughes bought M/A-Com Inc.'s VSAT operations, giving Hughes the second largest market share in 1987, according to Dataquest. Scientific-Atlantic acquired Adcom, giving the Atlanta-based supplier a place on the top 10 list of VSAT equipment and service suppliers.

Last year, AT&T took a large step forward in VSAT market share when it acquired Tridom Corp., a Marietta, Ga., VSAT manufacturer. The telecommunications giant then purchased Harris Corp.'s Pactnet satellite ground station technology in November.

The acquisitions binges are because of a trend in the market for one-stop shopping, according to Steve Sazegari, a telecommunications analyst with Dataquest. Sazegari expects to see more acquisitions because the strategy in the industry is to integrate VSAT hardware with full satellite service support. That way, customers can then turn to one vendor to lease satellite time, lease or purchase a network hub, buy VSAT equipment, software, service and network management.

Despite that, and industry-wide agreement that customers prefer one vendor to many, the handful of players in the market have different strategies. GTE Spacenet, for example, does not manufacture VSATs; the company buys NEC hardware. But GTE Spacenet does everything else, including selling the systems with proprietary software and leasing time on its own satellites.

"The VSAT is just one small part of it," says Ray Marks, vice president for marketing at GTE Spacenet. Also, the hardware component carries the lowest margins. The hardware, says Marks, "is probably less important than having the infrastructure to provide support, service and network management." For that reason, says Marks, GTE Spacenet will not become a manufacturer and will not acquire one.

Increasingly, VSATs are replacing existing phone lines in major metropolitan areas

NEC, on the other hand, only sells to original equipment manufacturers. "NEC is a quiet company," says NEC's Arcoria. "We like to stay away from the end user. It has worked in the past in other areas." Last year, the company, which has about 2,000 VSATs installed and counts 10,000 more on order, signed up six OEMs, including Nova-Net, which also resells Contel ASC and Hughes equipment.

Nova-Net, like GTE Spacenet, does everything but manufacture. Nova-Net's Mesch says there are three types of suppliers in the industry: manufacturers, such as NEC, that do not provide service; manufacturers, such as AT&T and Hughes, that provide systems and service; and turnkey suppliers such as Nova-Net that do not manufacture but supply end users with complete service.

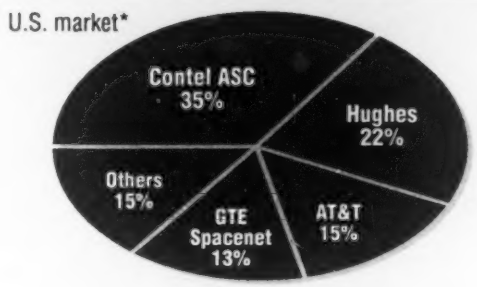
Another way to segregate it is by end user. Most VSAT service providers target large end users, such as Chrysler. Nova-Net, which has targeted the energy industry, also focuses on the small user with under 500 sites to service. Those customers, Mesch has found, are increasingly interested in leasing, rather than buying, the equipment and services.

The small customer is becoming a bigger segment of the market, says Yankee Group's Wiggins. The large end-user segment is near saturation, says Wiggins, and the greatest growth in the market over the next few years will be with smaller end users.

The market outside the U.S. is also expected to take off in a few years. Specifically, post-1992 Europe should see rapid growth, says Yankee Group's Wiggins and others, when deregulation of the telecommunications industry hits Europe the way it hit the United States five years ago. VSAT network suppliers are making arrangements in Europe. Hughes, for example, sells through a distributor owned by West Germany's Daimler-Benz AG and Satellite Technology Management Inc., a VSAT service provider in Costa Mesa, Calif., has a pilot system at West Germany's Postal, Telegraph and Telephone agency.

Those markets will become increasingly important, says Yankee Group's Wiggins, as VSAT networks evolve. Tomorrow's VSAT networks, says Wiggins, will succeed as part of a hybrid system including satellite and fiber-optic communications into one network. □

Top U.S. VSAT vendors

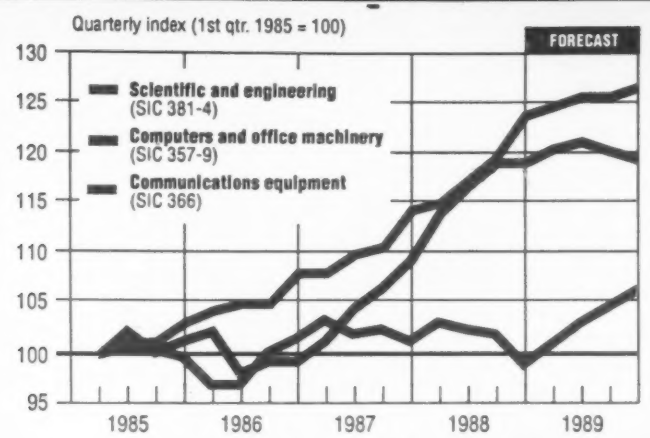


Total 1988 market: 25,000 VSATs

* For VSATs installed or on order

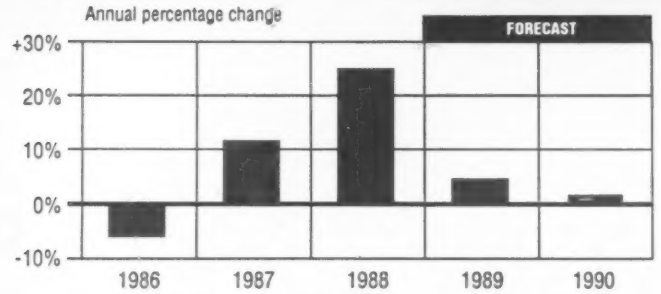
Source: The Yankee Group

Instrument production steadily rises



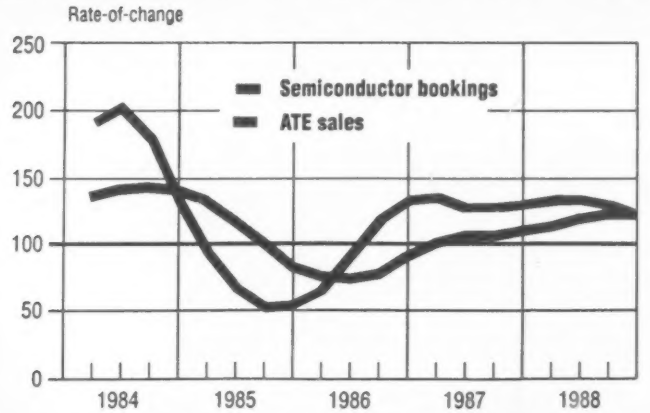
Historical data: Federal Reserve Board; Forecast: Cahners Economics

Automatic test equipment sales



Historical data: ELECTRONIC BUSINESS; Forecast: Cahners Economics

Semiconductor bookings versus ATE sales



Historical data: Semiconductor Industry Association, ELECTRONIC BUSINESS

Production stays on a steady growth path

Manufacturers of instruments and controls continued to churn out ever-more units during 1988. Average annual production in this industry increased 7.5% from the level in 1987. As a consequence, capacity utilization rates climbed, hitting 83.6% in October of last year. That was the highest monthly rate since the beginning of 1985.

Even with an impending slowdown in business investment growth, generally a driving force for gains in the test instruments and process control markets, the instruments industry is expected to make steady headway in 1989 and 1990. At least two of the big buyers of process controls, the chemicals and paper industries, operated at utilization rates brushing 90% or above. These industries are still busy modernizing plants and adding new capacity, and therefore, buying more equipment.

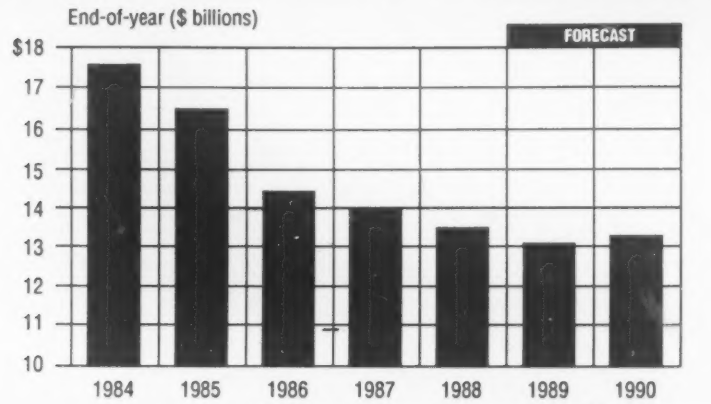
Since 1985, production gains in the instruments and controls industry have outpaced those in both the computer and communication equipment sectors. One reason is that instruments manufacturers did not suffer the pronounced slowdown in 1986 as did other electronic equipment makers. In fact, only during the 1975 and 1982 recessions did production of instruments actually decrease.

On the automatic test equipment front, the ELECTRONIC BUSINESS ATE Sales Index jumped to an estimated 888.0 (1976 Q1 = 100) in the fourth quarter of 1988 from a revised 836.1 in the third quarter. For all of 1988, the index shot up about 25% compared with the prior year. In dollar terms, the percentage gain brought worldwide sales to $2.24 billion in 1988. Sales are forecast to increase again, just under 5%, this year. This slower growth is in response to the contraction in semiconductor orders.

Monitoring business cycle developments in the semiconductor industry can give ATE manufacturers some early warning of expansions or contractions in their industry. The business cycle curve for semiconductor bookings (a plot of the rate-of-change values) has consistently led the curve for ATE sales during the entire 1984 through 1988 period. More importantly, it has given three to six months early warning of the last three business cycle turning points in the ATE industry.

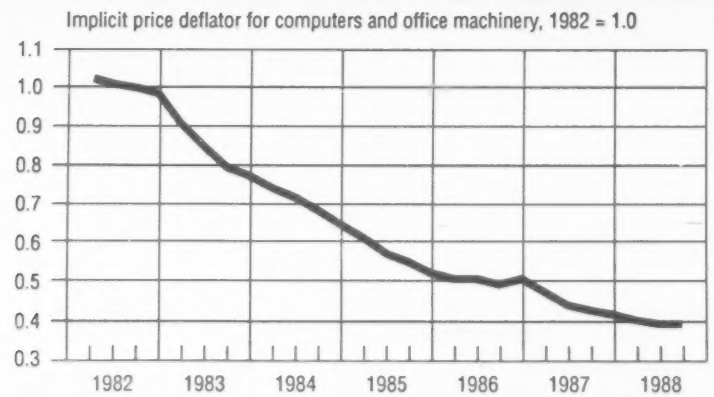
MADELINE FRANCHI

Computers and office machinery — Unfilled orders



Historical data: U.S. Department of Commerce; Forecast: Cahners Economics

Computer and office machinery prices are down



Historical data: U.S. Commerce Department

Shrinking backlogs a disturbing indicator

Although shipments of computers and office machinery grew almost 11% in 1988, the best year for growth since 1984, backlogs never recovered from their most recent plummet. At the end of 1984, unfilled orders for computers and office machinery tallied $17.6 billion, just about even with the year before. But, since 1985, the value of backlogs has been shrinking. Backlogs have steadily dwindled from $16.5 billion in December 1985 to just $13.5 billion at the end of 1988.

Because values are measured in current dollars, some decline might be expected. Prices of computer hardware have eroded over the past several years and the industry composition has shifted from mainframes to desktop computers. According to U.S. Commerce Department data, the implicit price index for computers and office machinery shrank by a little more than 10% just from the third quarter of 1987 to the same period in 1988.

Nevertheless, the fact that unfilled orders did not recover from the last downturn is disturbing. The industry does not have a large buffer to work off as growth in new orders for computer hardware and office equipment slows down this year.

MADELINE FRANCHI

Computer market database

Latest quarter: 4th quarter 1988	Latest quarter	Previous quarter	Change	Year ago	Change	Next year	Change
Industrial production (SA,1977=100, qtr. average)	320.3	319.0	+0.41%	293.6	+9.09%	320.5	+0.06%
Shipments (SA, $ millions, qtr. total)	$16,721	$17,406	-3.94%	$15,367	+8.81%	$16,742	+0.13%
New orders (SA, $ millions, qtr. total)	$16,480	$17,306	-4.77%	$15,204	+8.39%	$16,808	+1.99%
Unfilled orders (SA, $ millions, qtr. total)	$13,479	$13,720	-1.76%	$13,951	-3.38%	$13,059	-3.12%
Inventory-to-shipment ratio (SA, end of qtr.)	2.18	2.04	—	2.08	—	2.20	—
All employees (thousands, end of qtr.)	525.0	517.8	+1.39%	501.1	+4.77%	516.4	-1.64%
Production workers (thousands, end of quarter)	171.3	167.4	+2.33%	169.3	+1.18%	165.9	-3.13%
Exports ($ millions, qtr. total)	$6,266	$5,596	+11.98%	$5,419	+15.63%	$6,353	+1.39%
Imports ($ millions, qtr. total)	$6,310	$5,759	+9.56%	$5,719	+10.33%	$6,866	+8.82%

SA = seasonally adjusted, all other data is not seasonally adjusted

Data sources: Federal Reserve Board, U.S. Bureau of the Census and U.S. Bureau of Labor Statistics
All data for SIC 357, except industrial production, SIC 357-9. Forecasts: Cahners Economics

NOTE

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